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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Method of Sealing Boreholes, Tubes and the like and Apparatus therefor

We, MINERALIMPEX Magyar Olaj- és Bányatermék Külkereskedelmi Vállalat, a body corporate duly organised under the laws of Hungary, of 64, Népköztársaság utja, Budapest VI. Hungary, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of sealing boreholes, tubes and the like and apparatus therefor. In mining it has been proposed to seal boreholes at a predetermined depth by the provision of a cement plug, the insertion of a packing device or of some alternative closure means which can be later destroyed and removed by a drill. All these proposed methods have certain drawbacks. For instance a pouring pipe is required for producing a cement plug and the pipe must be inserted in the borehole and then withdrawn. Other equipment is also needed, such as drilling, sampling and probing devices. Moreover, cementing is an expensive procedure because the introduction and setting of the cement grout, drilling out the cement plug for removing the same and the assembly and dismantling of the auxiliary equipment are time consuming operations. For the introduction of a packing device rods are needed which also take time to assemble and to dismantle. This method is therefore also expensive.

Perforatable plugs which are lowered at the end of a cable are actually packing devices located by an explosive or some other form of energy supplied to the device from above ground or by mechanical bonding. They are actuated by the pulling force of the cable. Such plugs cannot be subsequently released. They must be removed by using the drilling rig.

These methods and the apparatus required to perform them therefore consume much time, material and labour; the apparatus is also complicated and therefore attempts have recently been made to put forward other proposals. For instance, hollow cylindrical plugs filled with an explosive have been lowered into the borehole, the explosive being detonated and the plug thereby deformed to wedge it tightly in the borehole and form a seal. However, the explosion usually damages the borehole. In view of this difficulty another proposal consists in using a plug made of an elastic material forced into a cylindrical chamber in a device lowered into the borehole. An explosive is used to shoot the plug out of its chamber for sealing the borehole. However, this method of providing a seal by the explosive expulsion of a plug has likewise proved unsatisfactory, partly because the position where the plug will lodge cannot be exactly controlled and partly because such plugs cannot generally be removed other than by drilling them out. Moreover, the handling of devices filled with an explosive is dangerous.

In another proposal a flexible tube to which a pump is attached is lowered into the borehole. The tube is expanded by the pump filling the same with the water contained in the borehole, the pump being then disconnected from the device.

This arrangement is complicated and consists of many parts, since its operation requires the provision of two electric motors, a pump, a tube as a sealing means, a valve system as well as all the parts associated with the current supply. The results achieved are also uncertain and the water in the borehole which may contain sludge or sand makes it impossible to reconnect

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the flexible tube to the pump. In other words, the sealing tube cannot be released and must be removed by drilling it out. Moreover, because of the sludge and sand in the water in the borehole the valve in the flexible tube cannot be reliably and permanently closed and the seal therefore ceases to operate properly after a relatively short period of time.

According to the invention there is provided a method of sealing boreholes, tubes and the like by means of a sealing device comprising an expandable jacket defining a chamber, said method comprising lowering the sealing device to the required depth in the borehole, increasing the pressure in the chamber by allowing medium in the borehole to communicate with a pressure amplifier comprised in the sealing device, said pressure amplifier being in communication with the chamber or by allowing a pressurised medium in a storage means comprised in the sealing device to flow into the chamber directly or through a pressure amplifier comprised in said sealing device, whereby the jacket is expanded into sealing contact with the walls of the borehole.

Substantially the method and the apparatus for performing the same according to the invention is based upon constituting the seal at a prescribed depth in the borehole or pipe section primarily by using the locally available hydrostatic pressure or —if this is not available—by using energy introduced from overhead and stored in the body of the sealing means, such as the compressed gas of a gas cylinder or energy contained in some suitable medium (for instance chemical energy) which can be released at the location required. The apparatus is lowered by means of a rope or cable. Leakage cannot occur and the seal can be released and removed by a special releasing device operable by the cable or rope.

Specific embodiments will now be described by way of example with reference to the accompanying drawings in which:

Fig. 1 is a section of the device which is operable by locally available hydrostatic energy and

Fig. 2 is a section of another embodiment operable by energy stored in the sealing device itself.

The form of construction illustrated in Fig. 1 is introduced and located inside the borehole by lowering it attached to the end of a cable so that the employment of drill rods or of a placing tube is not required. The necessity of assembling and removing such supplementary equipment does not therefore arise. Owing to the automatic operation of the embodiment according to Fig. 1 energy for operating the same need not be supplied from above ground. Consequently, the employment of this device and the performance of the method are quick and cheap.

The sealing device which has been assembled above ground as prescribed is lowered into the borehole 1 to the required depth by a cable or rope 2 which incorporates an electrical lead. When this depth has been reached an entry valve 3 is opened by means of an electrical pulse transmitted through a relay, by making use of a temperature rise caused by geothermal heat or by clockwork, chemical or other means. The liquid 4 inside the borehole is thus admitted through the open entry valve ports 5 into a chamber above a piston 7 which operates in the larger diameter portion of a cylinder 6 comprising chambers of different diameters. The piston is therefore forced downwards, exerting a thrust corresponding to the effective cross-section of the piston 7 times the available pressure. This thrust is transmitted through a piston rod 8 to a piston 9 working in a smaller diameter chamber for applying the thrust to a liquid 10 contained in the smaller chamber. Liquid 10 is therefore subjected to a pressure determined by the ratio of the cross sections of the two pistons. Piston 9 which applies the intensified pressure transmitted by the described hydraulic pressure amplifier displaces the liquid from chamber 10 through a pressure pipe 11, a non-return valve 12 and a channel 13 into a hydraulic chamber 14 and expands the cylindrical wall 15 of this chamber into sealing contact with the interior wall of the borehole casing 1. The sealing wall 15 embraces the head 16 of the device in the manner of a jacket and is anchored therein by bulbous projections which fit into corresponding recesses. This jacket is forced to expand substantially only radially since the shape of the head at 16 and 16*a* prevents any movement in other directions.

The closure head comprising the parts 15, 16 and 16*a* is connected by spacing rods 17 spring fastened at 18 to the baseplate 6*b* of the cylinder 6. The fluid pressure in chamber 14 rises to a level which is determined by the ratio of the surface areas of the two pistons 7 and 9 and by the head of water or other liquid in the borehole. It therefore remains constant at this level. As this pressure increases the sealing jacket 15 expands and is urged into contact with the walls of the borehole and thus seals the borehole above the sealing device from that below the device.

As soon as the seal has been established the supporting cable 2 is raised which causes the spacing rods 17 to pull out of their spring fastenings. Further raising of the cable ruptures the pressure pipe 11. However, fluid cannot escape because of the

presence of the non-return valve 12, so that only the bottom part of the device, the so-called plug, remains tightly wedged in the borehole casing. The upper part of the device, comprising the pressure amplifier can then be lifted out and withdrawn by means of the cable. The necessary sampling or producing operations can then proceed.

When the necessary work has been completed the sealing plug can be released by means of a special gripper or releasing means lowered at the end of the rope 2. The gripper grips a withdrawing head 19 and when the rope pulls the flange 19*a* upwards a shearing pin 21 is adapted to fracture the end of an exhaust pipe 20. The pressure inside chamber 14 can thus exhaust into the interior of the borehole through the open end of pipe 20 until the pressures are equalised. The seal thus collapses. The flange 19*a* strikes the heads 22 of the screws which are held in the plug and the entire sealing plug can be lifted out of the borehole by means of the rope.

After the pistons 7 and 9 have been reset and the pressure pipe 11 has been replaced the apparatus can be used again. The spring fastening 18 may have the form of a releasable catch built into the screw heads 22 and arranged to release when subjected to tension. The upper portion 16*a* of the sealing plug 16 may be threadedly connected to the rest of the plug, an arrangement which facilitates fitting or replacement of the sealing jacket 15.

The above described embodiment of the sealing device is only one of diverse possible forms of constructions. For instance, the energy which in the above described embodiment is provided by the hydrostatic head may also be provided from a storage container associated with the device and connected through the entry valve 3 to the larger diameter cylinder *6a* containing the piston 7, the piston 7 being operated by the pressure stored in the storage container.

Valve 3 may likewise be of diverse forms of construction. For instance, it may have the form of a fusible metal plug which can be heated by an electrical heating coil 23 or of a valve which is opened by a clockwork mechanism or alternatively it may be a closure element which can be released by chemical action or perforated by mechanical means. Timed actuating means which can be preset above ground could also be used.

The energy used for operating the apparatus may also be of different kinds. It may be hydrostatic energy, geothermal energy or energy released by chemical or physical reactions (for instance by gassification, evaporation and so forth).

An embodiment of such a kind is illustrated in Fig. 2. Parts in Figure 2 which correspond to parts in Fig. 1 bear the same reference numbers.

The sealing device can be lowered into the borehole either by gripper means engaging the withdrawing head 19 or by two ropes or cables 2 attached to lugs 24. Gas which is to enter the chamber 14 formed by the jacket 15 for expanding the jacket into sealing contact with the borehole is stored under pressure in a storage chamber 25 in the head 16 of the plug. The sealing device is then lowered to the desired depth in the borehole. The gas for generating the sealing thrust can be admitted into the chamber 14 by the passage of a current supplied through a cable 2*a* to a heating coil 23. The heat fuses a metal insert 27 and thereby opens a passage of communication between chamber 25 and tube 26. The compressed gas flows through tube 26 into the chamber 14 where it expands the jacket 15 and forces it into sealing contact with the walls of the borehole. When the plug has been tightly wedged in position the two ropes can be released from the lugs 24 by exerting an upward pull thereon. At the same time the cable 2*a* is broken.

For the purpose of releasing the sealing plug and withdrawing it from the borehole a gripper attached to a rope is lowered into the borehole, the gripper automatically embracing the conical withdrawing head 19 of the plug. When this has been effected the rope is pulled upwards. The withdrawing head 19 and baseplate 19*a* are thus pulled upwards against the heads of the fastening screws 22. A shear pin 28 traverses the stem of the withdrawing head. This applies a tensile load to the cross section of the releasing tube 29 of the sealing device thereby breaking tube 29. Consequently the compressed gas in chamber 14 can escape into the interior of the borehole through tube 26 and the gap below the baseplate 19*a*. The pressures in the borehole and inside the device thus equalise and the jacket 15 is no longer in sealing contact with the walls of the borehole. As the withdrawing head continues to be raised the baseplate 19*a* engages the screw heads 22 and thus entrains the head of the sealing plug which can thus be withdrawn from the borehole. The chamber 25 can be filled and possibly emptied through a valve at 30.

Since the sealing plug must also be capable of being removed when the borehole has been damaged, for instance when the casing is buckled, it is preferred to construct the sealing plug of a metal or alloy that can be easily deformed, such as aluminium, or of a soft metal casting.

The sealing plug can be re-used by repeating the procedure that has been described after the pressure amplifier or the energy storage chamber have been re-

charged.

WHAT WE CLAIM IS:

1. A method of sealing boreholes, tubes and the like by means of a sealing device comprising an expandable jacket defining a chamber, said method comprising lowering the sealing device to the required depth in the borehole, and increasing the pressure in the chamber either by allowing medium in the borehole to communicate with a pressure amplifier comprised in the sealing device, said pressure amplifier being in communication with the chamber, or by allowing a pressurised medium in a storage means comprised in the sealing device to flow into the chamber directly or through a pressure amplifier comprised in said sealing device, whereby the jacket is expanded into sealing contact with the walls of the borehole.

2. A method as claimed in Claim 1, wherein the pressurised medium is exhausted from the chamber into the borehole to deflate the jacket and enable the sealing device to be withdrawn from the borehole.

3. A method as claimed in Claim 2, wherein after withdrawal of the sealing device from the borehole, the storage means or the pressure amplifier is recharged whereby the sealing device can be re-used.

4. A recoverable sealing device for performing the method as claimed in any preceding Claim, comprising an expandable jacket defining a first chamber adapted to receive a medium capable of exerting pressure to expand the said jacket, a second chamber communicable with the first chamber so that the first chamber can be pressurised by pressurised medium from the second chamber, the first and/or second chamber being provided with one or more exhaust passages for exhausting pressurised medium from the or each chamber.

5. A recoverable sealing device for performing the method as claimed in any of Claims 1 to 3, comprising an expandable jacket defining a chamber, a pressure amplifier of the differential piston type, means for connecting the amplifier to medium in the borehole in which the device is intended to be used, a tube for connecting the amplifier to the chamber, spacing rods between the amplifier and the chamber for maintaining the amplifier and chamber in spaced-apart relationship, the pressure amplifier being separable by the release or fracture of said rods from the chamber when the device is in operation to seal a borehole, the device further comprising a conical withdrawing head movable so as to exhaust said chamber and thereby withdraw the chamber from the borehole.

6. A device as claimed in Claim 4 or Claim 5, wherein means are provided to actuate the device so that pressurised medium is led to the chamber, said means being operable by an electric current, by fusing of a metal insert by a preadjustable timing mechanism or by chemical action.

7. A recoverable sealing device substantially as described herein with reference to Figure 1 or Figure 2 of the accompanying drawings.

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2 SHEETS

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This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

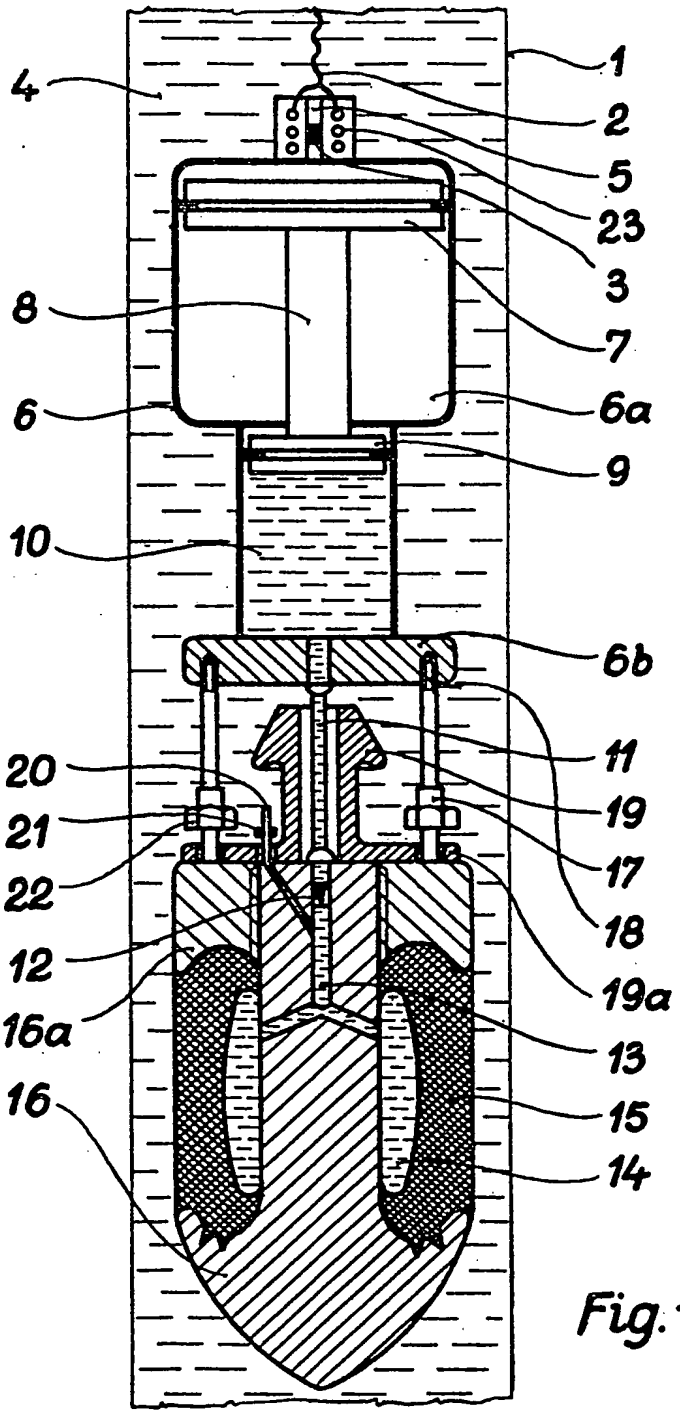

Fig. 1

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2 SHEETS

COMPLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale.
SHEET 2

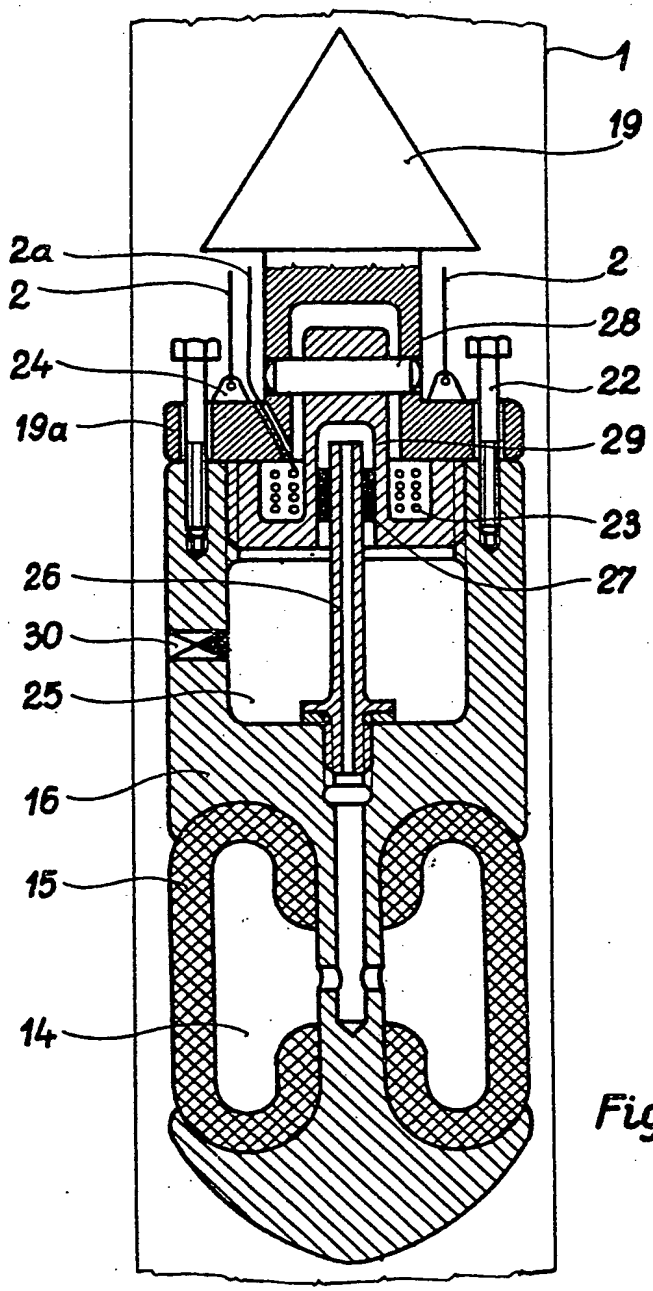

Fig. 2